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a progressive betterment of human character, the final, the most precious result of evolution on this earth.

GEORGE BRUCE HALSTED.

AUSTIN, TEXAS.

DETERMINATION OF THE CONSTANTS OF THE DIURNAL NUTATION.

(1) In the *Annuaire de l' Observatoire Royal de Belgique* for 1894, I gave the following results deduced from Gyldén's observations of the latitude of Pulkova:

Let κ = constant of annual aberration,
κ' = *reduced* constant of systematical aberration,

i. e., *projected on the equator*, which I derived from my terms of the second order which arise from the combination of annual and systematical aberrations.*

$\tilde{a}$ = parallax of Polaris;
ν = Peters's constant of nutation $9''.2235$;
n = the correction of this constant;
ν' = Peters's constant of the term $\cos 2 \odot : 0''.555$;
n' = its correction;
ν = the constant of the diurnal nutation;
L = the longitude of the *first* meridian,

i. e., the meridian which passes through the axis of the moment of inertia A of the solid crust of the globe.

Applying my formula, M. Byl, astronomer adjunct at the Royal Observatory of Belgium, has found

$\tilde{a} = 20''.408$. $\kappa' = 39''$. $\omega = 0''.0546$.
$n = 0''.003$. $n' = -0''.0444$.
$\nu = 0''.0665$. L = $12^h\ 0^m$ E. from Pulkova.

Illness has prevented M. Byl from coördinating his calculations, and I was compelled to make a new determination of both the last constants for the next volume of the *Annales de l' Observatoire Royal de Belgique*.

(2) My purpose was to make use of the excellent series of observations of the Polaris in Æ made at Dorpat by F. W. Struve, a series which had led me to conclude that the Eulerian period of 305 days was too short.*

In order to eliminate the variations of latitude, I have only used half of the sum of Æ observed at consecutive upper and lower transits. The laborious calculation of the whole series has given me unexpected results: $\nu = 0''.17$, twice or threefold too great; $L = 12^h\ 10^m$ E. from Pulkova, good result; $n' = +\ 0^j.045$, which is in complete discordance with the value $n' = -0''.0444$ deduced from Nyrén's observations, and moreover, theoretically inadmissible. In seeking the cause of these unlooked-for results, I found that an error of sign I had noted down some years ago and considered as a simple typographical error has been used by Peters in all his reductions of Struve's observations. In his formulæ (p. 13 of *Numerus Constans nutationes*) he wrote with +, instead of —, the terms of nutation in 2 $\odot$, and calculated his reductions with this erroneous sign.

All my work had to be done over again, as will be the case for Peters's determination of the constant of nutation.

In order to eliminate this serious error I used Struve's residuals, corrected by increasing by 0.″2 the Delambre's constant he had used for his reductions, and to avoid the other errors of reduction I have formed the differences between successive pairs of observations chosen so that the coefficients Σ_1 and Σ_2 were sufficiently different in both pairs.

(3) The diurnal nutation in Æ is in the meridian

$$\Delta a = -\, tg\ \delta\ (\xi\ \Sigma_2 + \eta\ \Sigma_1),$$

where $\nu = \nu \sin (2\,\mathrm{L} + a)$, $\eta = \nu \cos (2\,L + a)$; we may write

$$\Delta a = x\ \Sigma_2 + y\ \Sigma_1 = ax + by.$$

The principal terms I have used for the calculation of a (Σ_2) and b (Σ_1) are

*Catéchisme correct d'astronomie sphérique (Memorie della Pontificia Accademia dei nuovi Lincei, Roma. Vol. IX.), and Annuaire de l'Observatoire Royal de Belgique pour 1894, p. 346.

*Annuaire de l'Observatoire Royal de Belgique pour 1891.

$$a = -0.18 \sin \Omega + 0.39 \sin 2 \odot + 0.89 \sin 2 ☾ + 0.18 \sin (2 ☾ - \Omega).$$

$$b = -1.155 - 0.134 \cos \Omega + 0.36 \cos 2 \odot + 0.82 \cos 2 ☾ + 0.14 \cos (2 ☾ - \Omega).$$

writing, with Peters,

$\pm v$ = correction for the position (E or W) of the circle; w = correction of the mean Æ of Polaris, and remembering that the correction of the terms in $2 \odot$ has been eliminated by taking the difference between two pairs of observations, we have only the equation of condition

$$a\,x + by \pm v + w + n = o;$$

the unity of the residual, n, is the second of time.

(4) By taking the differences between the equations formed for such a pair of upper and lower culminations, two by two, it is clear that we shall obtain the simpler equation

$$(a_2 - a_1)\,x_2 + (b_2 - b_1)\,y + n_2 - n_1, = o,$$

which we write

$$ax + by + n = o.$$

The following table gives the values of p weights of the two equations used; a, b, n, n', multiplied by 100; the point after a number signifies 0.5. n' is the new residual obtained after the substitution, in each equation, of the values found for x and y.

	p.	*a.*	*b.*	*n.*	*n′*
1822. Nov. 5 and 12	(1.4)	—182	— 10	—87	—88
1823. May 6 and 16	(1.2)	—138	+ 77	6	— 5
" 16 and 19	(1.2)	—110	— 82	33	45
" 19 and 21	(2.3)	— 26	+ 56	—36	—45
" 21 and 30	(3)	— 29	145	14	8
May 30 & June 2	(3.4)	— 84	47	—10	4
Sept. 8 and 11	(1.2)	— 53	120	2	—17
Oct. 9 and 11	(1.2)	58	— 12	15	18
" 11 and 13	(2.3)	63	— 52	—34	—25
" 13 and 28	(3)	— 28	— 39	—37	—32
" 28 & Nov. 8	(2.3)	— 17	80	37	24
Nov. 8 and 14	(1)	63	50	—59	—66
" 14 and 26	(1.2)	—132	— 96	23	37
" 26 & Dec. 8	(1.2)	— 88	— 38	—15	— 8
1824, Apr. 6 and 11	(1)	—102	—175	—90	—63
" 11 and 23	(1.3)	81	149	+79	+56
" 23 and May 1	(2.3)	— 76	+ 58	—30	—40
May 1 and 3	(1.2)	55	— 10	72	74
" 21 and 22	(2.4)	— 72	— 15	—25	—24
" 22 and 28	(2.3)	— 6	—199	—23	— 1
" 28 & June 2	(1.3)	— 96	—146	—15	10
June 2 and 7	(1)	— 33	— 37	43	48
" 7 and 9	(1)	—119	114	64	44
" 9 and 12	(1.2)	144	25	— 7	— 9
" 12 and 17	(1.2)	— 5	—136	15	37
" 17 and 22	(1.4)	—121	62	—19	—30
Sept. 22 and 25	(2)	—100	70	— 7	—20
" 29 & Oct. 3	(2)	+156	— 16	—27	—22
Oct. 18 and 22	(1.2)	—142	65	26	14
Nov. 20 & Dec. 5	(1.2)	53	29	—61	65
Dec. 5 and 19	(2)	62	17	—41	43
1825. Mar. 15 and 17	(2.3)	— 54	— 61	—33	24
" 17 and 20	(2.3)	—102	57	2	— 9
" 20 & April 1	(2.3)	45	— 38	51	58
April 1 and 8	(2)	12	—116	70	51
May 1 and 7	(1.3)	147	44	—82	87
" 7 and 10	(1.3)	3	— 52	—18	—10
" 10 and 18	(1.4)	—125	84	2	—13
June 1 and 3	(3)	— 59	— 40	27	+33
Oct. 2 and 5	(1.3)	— 30	—110	—49	—32
" 3 and 4	(1.2)	35	— 9	11	+13
" 22 & Nov. 7	(1.2)	— 62	— 0	34	+33

(5) From this system we have deduced the normal equations

$$3882.5\,x + 142.6\,y - 27.6 = 0$$
$$142.6 \quad + 3801.7 \quad + 613.9 = 0,$$

which gives

$$x = 0^{s}.013 \pm 0.0044$$
$$y = 0.162 \pm 0.0049,$$

Where we deduce from

$$x = -\nu\, tg\, \delta \sin (2\,L + a)$$
$$y = -\nu\, tg\, \delta \cos (2\,L + a)$$

$\nu = 0.''070 \pm 0.''0019.$
$2\,L + a = 357° \; 20' \pm 46'.$
$2\,L = 342° \; 52' \pm 46'.$
$L = 11^{h} \; 25^{m}.7$ E. from Dorpat
$= 11^{h} \; 11^{m}$ E. from Pulkova.

The agreement between the constants deduced from Gyldén's observations of Polaris in Declination $\nu = 0.''0665$, $L = 12^{h} \; 0^{m}$ E. from Pulkova, and from Struve's observations in Æ, together with all the determinations I have made of these constants since 1888,* and with the smallness of the

* Annuaire de l'Observatoire Royal de Belgique, 1888–1894.

probable errors, is an irrefutable proof of the diurnal nutation.

The observations of Peters on the latitude of Pulkova had given me* $\nu = 0.''17$, $L = 11^h\ 58^m$ E. from Pulkova. But these observations are not nearly so precise as Gyldén's and have given a constant much too great.

(6) In order to corroborate my own conviction, I tested the determination of these constants by means of a short series of observations, treated like the preceding of Struve. This series is from Preuss' observations (1838, May 18–June 29).

In this case again the equation will be

$$ax + by \pm v + w + n = 0.$$

The following table gives the values of p, a, b, n. For such a short series we could not introduce the correction of the term $\sin 2\odot$, and we can expect a much too great value for ν. Our criterion will also be the longitude L.

1838	p	a	b	± 1	n (in sec. of arc)
May 19	4	0.56	—0.55	+1	— 3.″14
28	2	—0.53	—1.51	—1	— 5.94
May 29, June 1	2	—0.33	—1.04	—1	—10.6
June 7	4	0.79	—2.34	—1	— 1.67
9	3	—0.0167	—2.64	—1	+ 3.03
11	4	—0.742	—2.40	—1	— 7.14
June 13	4	—0.713	—1.19	—1	— 8.64
19	1	1.01	—1.96	+1	—15.0
27	3	—0.443	—0.96	—1	— 4.92
29	4	—0.193	—0.70	+1	—0.113

(7) From this system we have deduced the normal equations

$-\ 3.25\,x$	$-46.6\,y$	$-\ 7\,v$	$+31\,w$	$-108.03 = o$
5.60	+26.9	+31	— 7	+ 79.55
10.46	+ 4.01	+ 5.6	— 3.25	+ 24.92
4.01	+88.0	+26.9	—46.58	+ 82.22

whence

$x = 5''.6 \qquad y = 15''.4 \qquad v = -11''.3 \qquad w = 20''.7$

All these values are very great, which arises from the size of the residuals. It is to be noticed, however, that the signs of v, u, w are the same as those deduced by Peters from all the observations of Preuss.

From x and y we deduce $tg\ (2\,L + a)$, whence $L = 12^h\ 8^m$ E. from Dorpat, which agrees very well with all the preceding determinations.

(8) I will now give still another remarkable example of deductions, and one which shows the diurnal character of this nutation. For this case I have given the formulæ referred to the equator, which dispense with the calculation of the functions Σ_2 and Σ_1†. From these formulæ I have deduced the following expressions for the diurnal nutation in obliquity, $\Delta\theta$, and in longitude $\Delta\lambda$:

$$\begin{aligned}\Delta\theta &= y\left\{(\Sigma_1 \sin\varsigma'_1 - \varsigma_1 \sin R'_1) + 2.18\,(\Sigma_2 \sin\varsigma'_2 - \varsigma_2 \sin R'_2)\right\}\\ &\quad + x\left\{(\Sigma_1 \cos\varsigma'_1 - \varsigma_1 \cos R'_1) + 2.18\,(\Sigma_2 \cos\varsigma'_2 - \varsigma_2 \sin R'_2)\right\}\\ \operatorname{Sin}\theta\,\Delta\lambda &= x\left\{(\Sigma_1 \sin\varsigma'_1 - \varsigma_1 \sin R'_1) + 2.18\,(\Sigma_2 \sin\varsigma'_2 - \varsigma_2 \sin R'_2)\right\}\\ &\quad - y\left\{(\Sigma_1 \cos\varsigma'_1 - \varsigma_1 \cos R'_1) + 2.18\,(\Sigma_2 \cos\varsigma'_2 - \varsigma_2 \sin R'_2)\right\}\end{aligned}$$

in which the index 1 is referred to the Sun, 2 to the Moon. The notations are the following:

$$\Sigma = (1 + 6_2)\sin(1 - \tfrac{1}{2}\varsigma_2)\,A\,t,\quad \varsigma = (1 + S_2)\sin(1 - \tfrac{1}{2}\varepsilon_1)\,\Delta t,$$

Δt being the interval between the two observations.

$$6_2 = \tfrac{2}{3}\iota_2\frac{C-A}{A},\quad S_2 = \tfrac{3}{2}\varsigma_2\frac{C-A}{A}\ 1\ \frac{C-A}{A} = 0.00328.$$

$$T_2 = a_2 + 2\,d_2\ ;\ \tau_2 = a_2 - 2\,d_2,$$

* Ibid., 1894.

† *Theory of the diurnal, annual and secular motions of the axis of the earth.* Brussels. 1884.

a_2 and d_2 denoting $\frac{a_1}{n}$ and $\frac{d_1}{n}$, a_1 and d_1 the mean motion of the perturbing body (Sun or Moon) in Æ and D, n the diurnal motion of the Earth.

$\varsigma' = S - 2\tau$, $R' = R - 2\tau$, τ being the mean between the sidereal times of both observations, $S = A + 2D$. $R = A - 2D$.

$A =$ Æ, $D =$ Decl. of the perturbing body, calculated for the time τ.

$$x = v \sin 2L', \; y = v \cos 2L', \; L' = L + \tau,$$

whence $tg\, 2L' = \frac{x}{y}$; $v = \frac{x}{\sin 2L'}$; $L = L' - \tau$.

The observations give $\Delta\alpha$ and $\Delta\delta$, differences between the residuals $n\alpha$ and $n\delta$ obtained by each observation; whence we deduce by means of the known formulæ of transformation $\Delta\theta$ and $\Delta\lambda$.

(9) The following table gives all the elements of the calculation, extracted from the "*Annales de l'observatoire de Kiev* (5 min. *W.* from Pulkova), Vol. I., Observations de la Polaris sime par Fabritius." All the calculations were kindly made by M. Niesten, astronomer at the Royal Observatory of Belgium.

Datum.	τ	Δt	$\Delta\alpha$	$\Delta\delta$	*by* $\Delta\theta$	*by* $\Delta\lambda$	S_1	R_1	S_2	R_2
	h m	h m					° ′	° ′	° ′	° ′
1879. June 17	17 25	4 53.5	......	......	0.4975 *n*	0.4737	132 39	39 3	111 31	11 35.5
" 20	17 45	4 9	......	......	9.8754 *n*	0.0340	135 55.5	42 7	150 47	53 58.5
" 21	18 33.5	2 31	......	......	9.9921	0.0590 *n*	136 50	43 2	158 59	74 0
" 22	19 49	0 53	......	......	9.6383	9.6798 *n*	138 5	44 19.5	164 19.5	95 44
" 25	17 22.5	4 52	......	......	9.5111	9.5828 *n*	141 4	67 3	169 3	153 19.5
Jul. 1	19 41	1 40.5	......	......	9.5488	9.8870 *n*	146 42	54 18	199 44.5	303 15.5
" 4	18 4	3 45	......	......	0.1130	0.1801 *n*	149 16	57 45.5	255 9	339 28.5
" 7	20 31	1 13	......	......	0.2992	0.3666 *n*	151 35	61 47	325 46	348 41
Aug. 9	20 8.5	4 51	......	......	9.8052	9.8693	170 52	107 38.5	82 5	358 36
" 17	20 20	5 28	......	......	0.3256	0.3920 *n*	173 34	120 5	167 31	124 9.5
" 18	21 17	7 26	......	......	0.1224	0.1884	173 50.5	121 43	168 51	149 48.5

Whence the following equations, where the numbers are expressed in logarithms:

					v	$2L^1$	L^1	L
					″	° ′	h m	h m
17 June	1879.	1.3529 y 0.5659 y	—0.1658 x +1.7530 x	=0.4975 *n* =0.4737	0.122	135.7	4 30	11 5
20 "	"	1.2713 y —1.1354 y	+0.7353 x +1.6713 x	=9.8754 *n* =0.0340	0.044	127.18	4 14.5	10 29.5
21 "	"	1.0142 y 0.6425 y	—0.2424 x +1.4143 x	=9.9921 =0.0590 *n*	0.104	132.20	4 24.5	9 51
22 "	"	0.4661 y 0.6055 y	—0.2054 x +0.8662 x	=9.6383 =9.6798 *n*	0.102	151.24	5 3	9 14
25 "	"	0.6698 y —0.3485 y	+9.9484 x +1.0699 x	=9.5111 =9.5828 *n*	0.076	127.32	4 15	10 52.5
1 June–Oct.	"	0.3477 y 1.2464 y	—0.8464 x +0.7478 x	=9.5488 =9.8870 *n*	0.063	154.18	5 8.5	9 27.5
4 "	"	1.1805 y —1.1661 y	+0.7660 x +1.5806 x	=0.1130 =0.1801 *n*	0.119	201.00	6 42	12 38
7 "	"	—9.9292 y —0.7693 y	+0.3691 x —0.3293 x	=0.2992 =0.3666 *n*	0.095	166.16	5 32.5	9 1.5
9 Aug.	"	—1.9162 y —0.3163 y	—1.1526 x +1.5527 x	=9.8052 =9.8693	0.050	142.56	4 45.5	8 37
17 "	"	1.0950 y 0.8918 y	—0.4917 x +1.4951 x	=0.3256 =0.3920 *n*	0.114	167.25	5 45	9 25
18 "	"	0.9663 y 1.2182 y	—0.8181 x +1.3664 x	=0.1224 =0.1884	0.128	180.30	6 1	8 44
				Mean,	0.091			g 58.6

The agreement between these various determinations is truly most satisfactory, so much the more so as many of them (the 4th, 6th and 8th), are from observations whose interval does not reach two hours.

It is sufficient to establish, not the values of the constants (the number of observations is too small), but the existence of diurnal nutations.

(10) In conclusion, I believe astronomers

may at once introduce in their reductions my expressions of the diurnal nutation, employing the constants:

$$\nu = 0''.07,\ \mathrm{L_o} = 1^{\mathrm{h}}.5 \text{ E. from Greenwich.}$$

My formulæ are, *in the meridian*:

$$\Delta a = -\,tg\,\delta\,(\eta\,\Sigma, + \xi\,\Sigma_2).$$
$$\Delta\delta = -\,\xi\,\Sigma_1 + \eta\,\Sigma_2$$
$$\xi = \nu \sin\,(2\,\mathrm{L} + a);\ \ \eta = \nu \cos\,(2\,\mathrm{L} + a);$$
$$\mathrm{L} = \mathrm{L_o} + \lambda$$

λ denoting the longitude of the observatory, W. from Greenwich.

$$\Sigma_1 = -\,1.155 - 0.134 \cos \Omega + 0.36 \cos 2 \odot$$
$$+ 0.82 \cos 2 ☾ + 0.14 \cos (2 ☾ - \Omega) - 0.13 \cos (☾ - \Gamma')$$
$$\Sigma_2 = -0.18 \sin \Omega + 0.39 \sin 2 \odot + 0.89 \sin 2 ☾ +$$
$$0.18 \sin (2 ☾ - \Omega)$$
$$+ 0.07 \sin (3 ☾ - \Gamma') + 0.07 \sin (☾ - \Gamma'),$$

where the arguments are true longitudes.*

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CURRENT NOTES ON PHYSIOGRAPHY (XVII.).

THE LABRADOR PENINSULA.

THE last few years have added much to our knowledge of this inhospitable region. Besides the Bowdoin expedition to the Grand falls of the Hamilton river, Low and Eaton, of the Canadian Geological Survey, traversed the interior by several routes (London Geogr. Jour., June, 1895, 513–533, map) and Bell, of the same survey, gives an excellent summary of his own explorations and of all available material (Scot. Geogr. Mag., July, 1895, 335–361, map). Labrador is a moderately elevated plateau, averaging 1,800 feet above the sea, of Archæan rocks; hilly, interspersed with many lakes and swamps, and having a surface of bare rocks, alternating with numerous and large boulders and other glacial debris. Mountains rise along the northeast, north and northwest border, the loftiest being the first named, with summits reputed to be 8,000 or 9,000 feet high. These present steep sides and jagged crests, and are believed to have escaped the glaciation that ground so heavily over the rest of the region. The largest of the numerous lakes in the interior plateau —Mistassini—is a hundred miles long. Many lakes have two outlets. The rivers on the plateau do not flow in deep or well defined valleys, but are prone to spread over the country in straggling channels; branches turn off unexpectedly on either side and, after an independent course of from five to fifty miles, rejoin the main channel. Every river is broken throughout its whole course by falls and rapids at irregular but generally short intervals, thus necessitating many portages in canoe traveling. Canyons like that of Hamilton river, and fjords like that of the Saguenay, are explained by Bell as the sites of deep-weathered dykes, cleaned out by glacial action. Grand falls on the Hamilton occur where this river plunges down the side of the canyon, which continues for twenty-five miles to the northwest, although not occupied there by any considerable stream. Recently elevated beaches occur along the eastern coast, up to 500 feet above the sea. Excepting in the north, the plateau is generally forest covered, but the trees seldom reach two feet, and are generally less than one foot in diameter. Great loss is caused by forest fires. The population is very scanty; 18,000 total, or about one to thirty square miles; and most of these live near the St. Lawrence and Atlantic coasts. About a thousand schooners, many of which carry several families, go from Newfoundland to the Atlantic coast to fish in the summer.

TRANSVERSE VALLEYS IN THE SOUTHERN ALPS.

FÜTTERER concludes a careful study of the 'Durchbruchsthäler in den Süd-Alpen'

* The constant term of Σ indicates that each star position of every catalogue must be corrected with $\Delta\,a = \delta''.081 \tan \delta \cos (2\,L + a)$, $\Delta\,\delta = -0''.081 \sin (2\,L + a)$. The last form of correction has been detected empirically by Gould in his own catalogue of Cordoba, and has allowed me to reduce greatly the systematic differences noticed by Downing between the catalogues of Greenwich, the Cape and Melbourne. (See *Annuaire* for 1894, p. 348 and 372.)